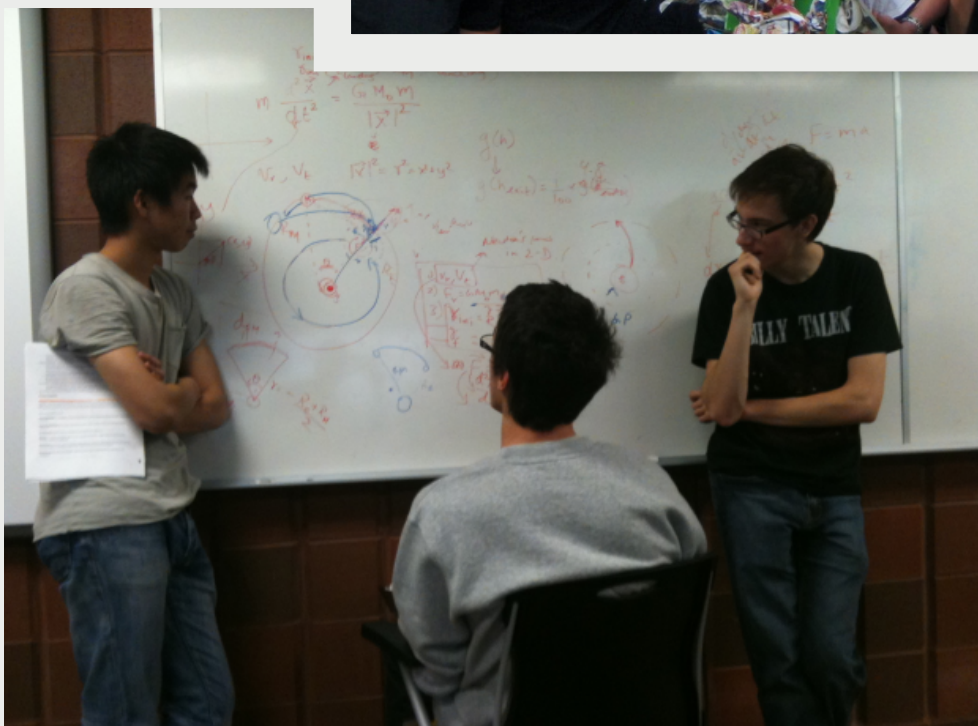


# EXPLAINING SCIENCE

Integrating Science Literacy Into a Research-Based  
Undergraduate Program

Andrew Colgoni,  
Sarah Symons, Chad Harvey  
and Carolyn Eyles



McMaster  
University





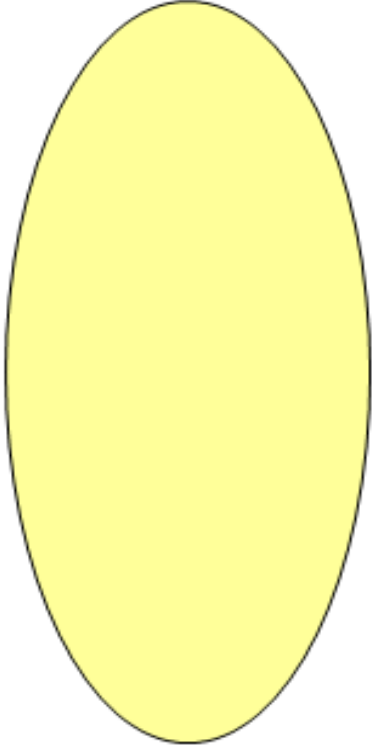


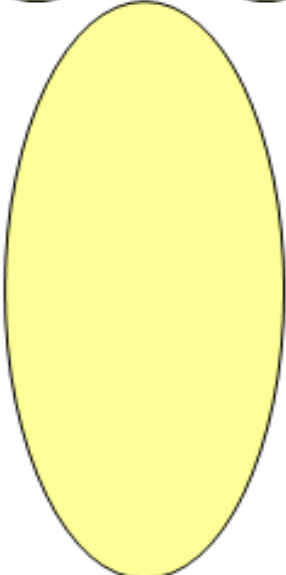
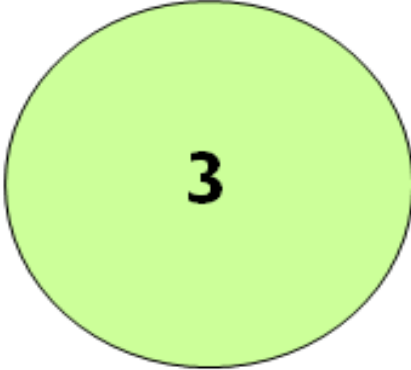
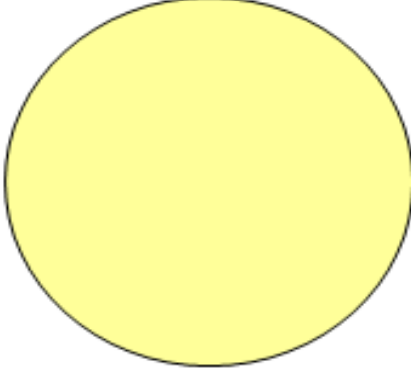
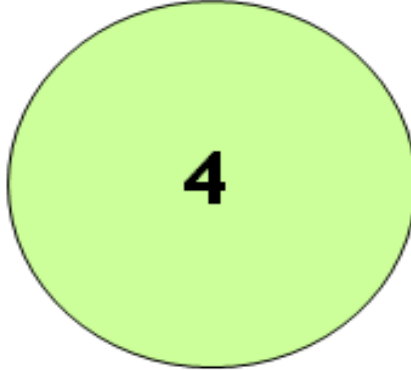
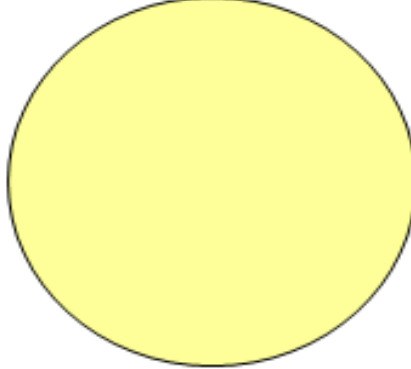
# Outline



1. About the Integrated Science program
2. The goals of Science Literacy
3. The implementation of Science Literacy

# What is iSci?

- New – introduced September 2009
- Interdisciplinary, research-based science program
- Limited enrolment program targeted toward highly motivated, high achieving students
- Small class sizes (max. 60/year)
- Collaborative, self-directed learning

# Research Project as Focus

Term 1		Term 2	
Foundation Concepts	Size & Scale	Energy	Populations
	  	 	 

 **Problem-based research projects**
 **Interactive teaching support**



# Mission to Mars

- Plan a manned / unmanned mission to Mars
- Make design decisions about: rocket design, propulsion, landing site
- Determine what you will research on the planet
- Write report and present results

Research Project 1: Mission to Mars  
Project Leaders: Drs Sarah Symons and Chad Harvey



Image: An oblique view of the Victoria Crater, in the Meridiani Planum region, by the Mars Reconnaissance Orbiter's High Resolution Imaging Science Experiment, NASA.

## Scenario

You will work in teams of four iScientists to develop proposals for a scientific mission to Mars. Each team will "pitch" their mission proposal to a panel of experts (instructors), who will be looking for viability, scientific worthiness, and communications of a motivated and competent team. You have three weeks to prepare your pitch, during which time you must learn to work together as a team, manage your time and resources, interact with iTeach members in the research project environment, and of course complete your individual learning requirements.



# Role of the Library

- Home-base in library
- Librarian embedded into program
- Students heavy users of ‘found’ information early on



# Science Literacy Vision

“The iSci program will also intentionally teach “literacy” in its broadest sense. This component will be one of its most distinctive features, unlike any other science undergraduate program in Canada.”

“Steps towards fostering scientific literacy will be embedded within the core components of the iSci program.”

-iSci Design Document, 2007



# Science Literacy Vision

- “Developing [writing] skills... frequently...”
- “poster session”
- “...best use of research resources”
- “...assessing [information] quality”
- “...instilling... research ethics”
- “...collaboration with... library representatives”

-iSci Design Document, 2007



# Science Literacy Model

Team Taught

Weekly 2hr class  
(level I)

Assessed Component  
(level I-IV)

project marks attached to  
drafts and / or final  
deliverables

non-project marks:  
blog writing, participation

# Outline of programming

- Regular scientific writing (blog)
- Project deliverables: presentations, posters, reports, debate, book creation, etc.
- Classroom activities



# Blogging

Mar 25 / Ad

## The Missing Xenon

Fluorine and xenon chemistry is a branch of science that is filled with groundbreaking and startling discoveries.

were once believed to be synthesized from xenon trioxide ( $\text{XeO}_3$ ) and xenon dioxide ( $\text{XeO}_2$ ). This came to an end with the first successful synthesis of xenon compounds.

Brock and Schroeder discovered that crystalline xenon occurred when 2 xenon atoms, at 78°C, precipitated from a gas.

## Three-Way Mutualism: Ants, Fungus and Bacteria

Ants are one of the few organisms that grow their own food. Ant agriculture is thought to have originated 50 million years ago in South America when ants entered a mutualistic relationship with the many species of fungus they harvest (Shultz 2009). In this relationship, ants nurture the fungus to increase fungal growth while it in turn provides the ants with a food source. This provides an efficient method of foraging for both organisms, indicating that the association of ants with fungus is highly evolved (Dugatkin 2009).

Fungus-growing ant species, belonging to the attine family, also protect their fungus gardens against parasites by introducing a third organism to the mutualistic relationship (Shultz 2009). Ants that work in a fungus garden have a white crust on their body that was discovered to be the bacteria *Streptomyces*. *Streptomyces* produces antibiotics specifically effective against *Escovopsis*, a parasite that causes the fungus serious harm. Less dangerous parasites are not susceptible to the antibiotics. Only the ants that work in the fungus garden were observed to have the bacteria on their body. These female worker ants are also responsible for starting a new ant nest and transmitting the bacteria to the new ant population. Ants pass the bacteria down to their offspring to ensure the next generation has the bacteria to protect their food source (Dugatkin 2009).

Attine ants clean the fungus garden by collecting the *Escovopsis* spores and hyphae in the gaster and placing them in their infrabuccal pocket. The infrabuccal pocket contains the *Streptomyces* antibiotics that kill the spores and hyphae. The ants then dispose of the dead spores and hyphae outside of the fungus garden (Dugatkin 2009).

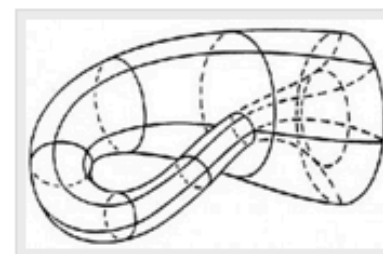
Ants have evolved an efficient method of cultivating food through their mutualistic association with fungus. They have also found a way of defending their food source by adding a third mutualist, *Streptomyces* bacteria, to the relationship (Dugatkin 2009). This complex mutualism illustrates the marvels of nature: long before humans even contemplated agriculture, three organisms developed an effective system of farming that has stood up to 50 million years of evolutionary testing.

### References:

Dugatkin, L.A. 2009, Principles of animal behavior, 2nd ed, W.W. Norton, New York.

Schultz, T.R. 2008, "Major evolutionary transitions in ant agriculture", Proceedings of the National

Another nonorientable surface is the Klein bottle. A Klein bottle (named after the German Mathematician Felix Klein, 1849-1925) is similar to a Möbius band in that it has only one side. In addition, Klein bottles have no boundary (no 'edge'); they are continuous, smooth surfaces. Klein bottles can be constructed from a rectangular sheet by attaching the long edges together without a twist, forming a cylinder, and attaching the short edge together after one half-twist (Stewart, 2010). Various Klein bottles are shown below.



dimensions, the surface of the Klein bottle must pass through itself in order to perform the half-twist. Topologists ignore this intersection, since it can be avoided in higher dimensions, but it is not possible to avoid when constructing a model in 3 dimensions (Stewart, 2010).

Because the fact that a Klein bottle has only one 'side', there is no 'inside' and no 'outside' to the bottle. The bottle is not a solid, but a surface, and therefore the volume of any Klein bottle is zero (Stewart, 2010).

## Force of Nothing: Casimir Force

The casimir effect describes a force generated by a quantized field and was mathematically discovered by Hendrik Casimir in 1948. It is a consequence of quantum electrodynamics that there is an attractive force between two uncharged metal plates due to zero-point electromagnetic field. The casimir force has two components: thermal and quantum. The thermal component is related to temperature and arises from thermal fluctuations in the field, while the quantum component arises from quantum fluctuations. Although the casimir force has been measured, it is still a topic of active research.



# Blogging

- peer-commenting required (participation)
- Feedback by TAs in comments
- One week for editing draft version
- Assessed: best three posts (students choice)

## Synopsis : Beta

Year II Integrated Science, McMaster University

Home Rules & Guidelines

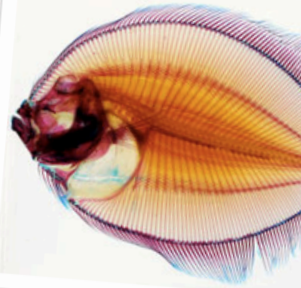
Feb 27 / James Boudreau

### Scientific Adventurers Past and Present

Most fields of modern science are relatively safe for those involved. Many discoveries and advancements are made in a lab under controlled conditions and, in the case where there is a high risk of danger, extensive safety precautions are taken to ensure the well-being of researchers. Indeed, even field work in exotic locations is relatively safe if researchers take the proper precautions and equipment. However, there is a small subset of scientists who have knowingly risked life and limb in the pursuit of knowledge. The following adventurers explored the far reaches of the Earth and beyond in the quest for scientific discovery.

Ferdinand Magellan was motivated both by economic incentives the drive to explore. Tasked by the Spanish crown with finding a westward trade-route to the lucrative spices of China, Magellan set out in 1519 with five ships (Rezende, 2006). In 1522, a single ship from the expedition arrived in Spain after having circumnavigated the globe. Magellan himself perished during the journey, however, his expedition was a success in both reaching China and discovering that the Earth had a continuous ocean and was approximately 25, 000 miles in circumference (Rezende, 2006).

Alexander von Humboldt (1769-1859) was, according to Charles Darwin "the greatest scientific traveler who ever lived" (Kellner, 2011). Humboldt was the first European explorer to scientifically study the South American continent, doing so at a time when only Spanish officials and the Roman Catholic Church were permitted to visit the Spanish colonies there. During his time in South America, he discovered the Andes, the Amazon, and the Pacific Ocean.



RECENT

Not So Bi-winning

Skin Deep – A Look at Plant-based Dermatology

Women are from Mars, Men are from Venus, and the Rest are from Venus

Klein Bottles

## Synopsis : Alpha

Year I Integrated Science, McMaster University

Home Rules & Guidelines

Mar 25 / Thilakshan Arulnesan

### Sabre-Toothed Herbivore

When one thinks of a sabre-toothed creature, the first image that usually comes to mind is a carnivorous sabre tooth tiger. It is hard to visualize any other purpose of a sabre tooth other than for predation. However, this is not always the case, as demonstrated by the newly discovered fossil of a therapsid (pre-mammalian ancestor) that is approximately the size of a large dog, and is appropriately named *Tiarajudens eccentricus*, loosely meaning eccentric teeth (See figure 1) (Handwerk, 2011).



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# Project Deliverables

- High-stakes, collaborative project work
- Varies: Written Report + Presentation / Poster / Debate
- History of the Earth: book

# Classroom Activities

- Usually involves pairing a short lecture with a longer activity
- Often tied to deliverables
- Offer a variety of instructional methods, including: discussions, clicker quizzes, peer feedback, worksheets, lecture, etc.
- Revisit themes: communication, academic integrity, writing, information literacy



# Information Literacy

- Distinguishing btw. sources, using databases, advanced searching, RefWorks, citing
- Often just-in-time
- Might be a quick lesson or a full activity, depending

## LIBRARY 101

How and where to find good information.  
Andrew Colgoni. Science Fluencies Librarian.

## Searching PubMed

Adapted for iSci  
Original by Jackie Stapleton (University of Waterloo)

# Evaluating Sources

- Students worked in small groups, each at a computer.
- Each group given a URL to a website.
- Evaluated website and then reported to the class on their verdict.
- Each website could be seen by the whole class.



# Presentation skills

- Watch and critique videos of presentations
- Collaborate on best practices document
- Provide students with low stakes practice

## **Presentations: The iSci Guide to Best Practice**

### **Preparation**

- Use props as necessary (i.e. cue cards and visuals)
- **Practice, practice practice!**
- Preparation brings up the choice between memorization and speaking extemporaneously; choose wisely according to personal preference.
- Know your content back to front, but don't memorize a script.
- Test the technology
- Have a back-up plan
- If presenting in a group, be sure that there's no overlap in content; aim for good flow
- Stay calm
- Wear appropriate clothes
- Coherence between sentences
- Don't fidget; it's extremely distracting for people sitting in the audience
- Do not chew gum while presenting

### **Structure**

- Introduction, main headings throughout, conclusion
- Try to have logical sequence of slides, so that the presentation flows

# Poster design

- Send students out into the campus to find posters. Get them to photograph and then come back to discuss.
- Offer guidelines on creation, formatting, etc.
- Feedback on draft version

## How to make a poster



Integrated Science – November 9<sup>th</sup>, 2010

### First Step



- ✎ Always, always determine what the poster requirements are for the session you're presenting at.

"Poster should be prepared in "portrait" format. The size of the poster must not be bigger than 98 cm width x 150 cm height. Poster material must be prepared in advance and must be large enough to be viewed from a distance of 90 cm. All posters must be written entirely in English. Lettering should be at least 1.0 cm high for good visibility. Each poster must have a top banner indicating the title of the paper, the names of the authors and their affiliations. The characters in the banner must be at least 2.5 cm. Drawings and graphs should be simple with bold lines."



# Future Planning

- End of year symposium
- Level Three project deliverables: podcasting, web magazine, instruction
- Independent study project
- Tweaking Level One class

# In Conclusion